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Nonlinear electrostatic excitations in electron-beam plasmas

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A number of satellite observations have confirmed the presence of electron beam in the upper layer of the Earth's magnetosphere, where a coexistence of two different electron populations (warm and cold inertial electrons) occur. In the presence of electron beam, stationary nonlinear localized electrostatic structures are excited in a plasma system. It has also been indicated that the solar wind injects the electrons which drift in the upper layers of Earth's magnetosphere. These electrons tend to perturb the magnetospheric plasma and hence give rise to nonlinear excitations and transform the conditions for the existence of nonlinear structures. Numerous theoretical investigations have confirmed the existence of nonlinear electrostatic structures in various space and astrophysical environments in the presence of electron beam [1-5]. It has also highlighted in different findings that the nonlinear potential structures (solitons, shocks, double layers, freak waves etc.) are significantly modified by the presence of electron beam and other plasma parameters.

The presence of superthermal particles in most of the astrophysical, space and laboratory environments have been confirmed by different satellite observations. Lorentzian (kappa) distribution function is the most common distribution used to model the superthermal particles in space environments. First time, Vasyliunas (1968) described in detail about kappa distribution which was employed to analyse energy ranges of electrons inside the space environments. The high-energy electrons follow a non-Maxwellian power law distribution, known as kappa distribution. In various space plasma situations, the velocity distribution of plasma particles at low energy is Maxwellian, while at high energies, it is non-Maxwellian which shows superthermal power-law tail. It is also confirmed that kappa-type distribution is more appropriate than Maxwellian distribution to model the space data. It has been reported that the investigation of the velocity distributions observed in the solar wind, planetary magnetosphere and magneto-sheath by the spacecraft showed that non-Maxwellian distribution of charged particles are very common. Saini and Kourakis (2010) reported the study of large amplitude ion acoustic solitary structures in a plasma consisting of inertial ions, superthermal electrons and electron beam. They observed that both polarity solitons are formed under the influence of beam parameters and other plasma parameters. Lakhina et al. (2011) discussed about ion and electron acoustic solitons and double layers in multicomponent space plasma consisting of ions, electrons and two electron beams. They analysed the influence of various plasma and beam parameters on the propagation properties of ion and electron acoustic solitons and double layers formed in this plasma system. In the recent past, Danehkar (2018) reported the study of electron acoustic solitary waves in electron beam plasma system in the presence of superthermal electrons. It was observed that both polarity electron acoustic solitons are formed and their characteristics are greatly affected by the variation of different plasma parameters.

Owing to the existence of electron beam and superthermal electrons in different space environments, it is interesting to derive nonlinear equations in such plasma environment taking into account presence of electron beam and derive their solutions for the study of properties of nonlinear electron acoustic structures. Main focus of this talk is to discuss about study of investigation of various kinds of electron acoustic nonlinear structures (viz. solitons, Freak waves, and Peregrine solitons) in multicomponent space plasma having cool electrons, ions, hot electrons obeying kappa distribution and embedded with electron beam. The reductive perturbation method is employed to derive Korteweg-de Vries (KdV) equation and nonlinear Schrodinger equation (NLSE). Further, using single variable transformation, solutions of these equations have been derived to study the characteristics of KdV solitons and freak waves as well as Peregrine solitons. It is observed that various plasma parameters have great influence on the propagation properties electron-acoustic solitons, freak waves and Peregrine solitons. This study may have variety of potential applications for better understanding of nonlinear phenomena in various space/astrophysical environments.

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